Using SINAD voting combiners in mobile radio networks

SINAD voting systems improve wide-area coverage on common channels. Voting frees operators from selecting zones and channels. Diversity reception can improve performance.

By A.O.J. Woodfield

Traditional land mobile radio systems include communications among a dispatcher at a fixed location and operators who use various mobile and portable units.

The base station might be installed at the fixed location where dispatching takes place. If that location is unfavorable for radio coverage, the communications range may be limited.

Woodfield is manager of Uni-Lab New Zealand, Christchurch, New Zealand. When this article was written, he was systems manager at Tait Communications, Christchurch.

The base station might be installed at a more favorable location and remotely controlled from the dispatch location to improve coverage.

The system may use a repeater station on a high building or geographic feature to relay communications throughout a fairly large area.

When even greater range is required, two or more repeaters may be connected by radio links, microwave links or telephone lines to combine their coverage areas. Linking allows all members of a fleet to monitor and use a common audio channel. Such systems usually require the mobile users to select the appropriate channel for the area in which they are located. Because the correct channel may not be immediately obvious to users traveling across many different repeater coverage areas, it is not uncommon to find many incidents of lost calls or poor communications because users select the wrong channel.[1]

Mobile receiver scanning is one way to solve the problem. The scanning receiver switches automatically from channel to channel until a signal is found. Unfortunately, a simple scanner locks onto any received transmission, not necessarily on the best available channel.

Another solution is to use quasi-synchronous transmission methods in which all transmitters, controlled by highly stable oscillators, broadcast simultaneously on a common channel.[2] Quasi-synchronous transmission is expensive, and its maintenance requires great care and relatively expensive test equipment.

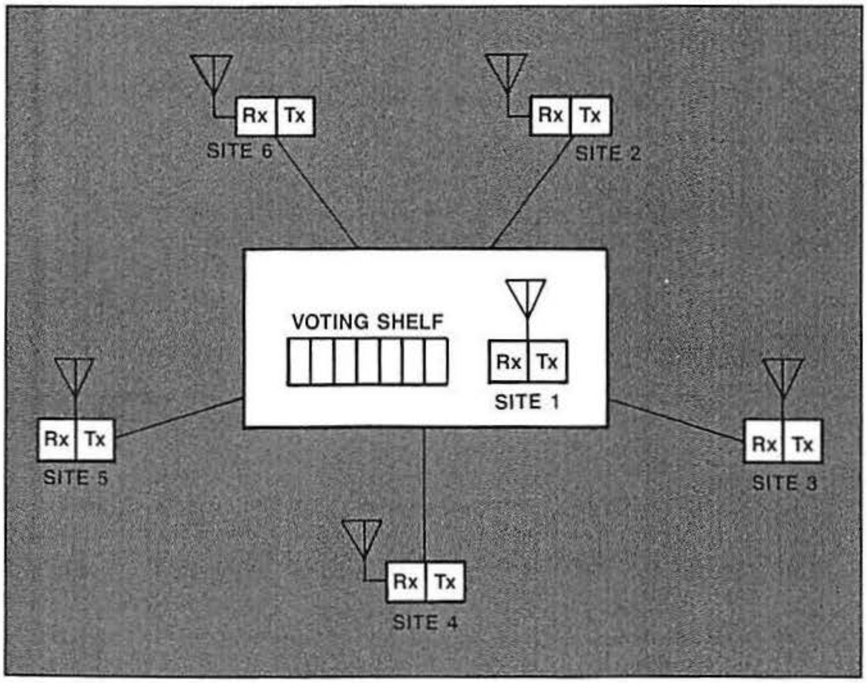


Figure 1. In the more common star network, satellite receivers are placed throughout the coverage area. They feed signals to a centralized voting shelf.

Mobile voting

A mobile voting system includes receiver scanning, but with an important addition: When a signal is received on any of the scanned channels, the mobile scans once more through all of the other channels and measures the received signal strength on each one. It selects the channel with the strongest signal.

The process requires a fast mute response time in the mobile and a fast signal strength measuring capability. A typical mobile scanning five channels may require 450ms (milliseconds) to complete the cycle before receiver audio is switched on. It takes about 50ms per channel to unmute; another 30ms per channel to measure the signal strength; and another 50ms to compute the result, select the channel and unmute again to allow the operator to hear the message. Until then, the audio output remains silent.

When continuous-tone controlled squelch system (CTCSS) is involved, the process takes more time. If the detection of a valid tone is left until the last stage in the process, it may increase the delay by 100ms to 200ms for a 650ms delay. For a system with CTCSS and 10 channels, a second may elapse before audio is heard, a delay that is unacceptable to most operators.

Some mobile voting systems require the permanent presence of transmitter carriers to operate properly. Such a requirement is inefficient, and it creates a potential source of interference.

Another problem with these wide-area coverage systems is the rapid rise in channel requirements. In many cases, the greater channel numbers can result in significantly reduced channel loadings and a consequential rejection of channel requests by local regulatory authorities.

The increasing use of portable transceivers adds problems for the network designer. Although a hand-held receiver's sensitivity may approach that of the usual mobile receiver, the lower transmitter output level, typically 5W (+37dBm), coupled with the lower efficiency of a shortened, helical antenna, results in significantly reduced portable coverage. To cope, system designers may add fill-in repeaters with additional linking, adding to the channel and linking requirements.

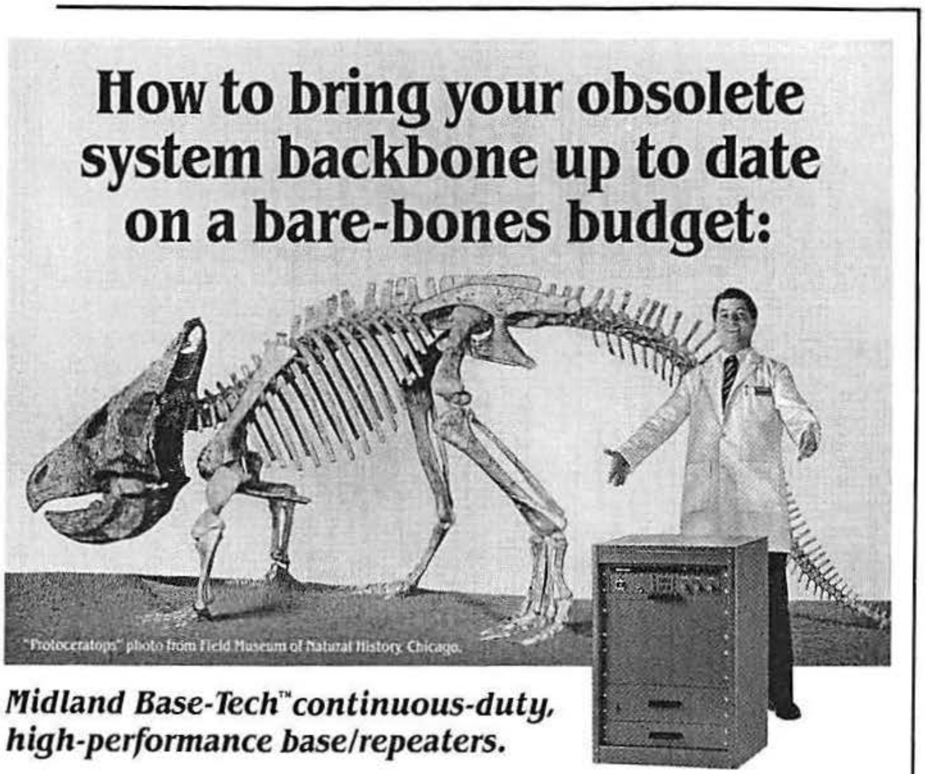
For larger networks, link channel requirements can be substantial. If UHF radio links are used, basic equipment design limitations, such as audio signal-to-noise performance and distortion figures, can limit the number of possible links.

Sinad voting

Sinad voting systems offer a solution. They help to cover a wide area with multiple radio channels; reduce RF channel and linking requirements; and support selective signaling, data transmission and CTCSS in much the same way they are used in conventional repeaters.

The sinad voting system continuously measures received audio from receivers within the coverage area. The sinad of all of these audio signals, usually represented by a fluctuating dc voltage, is passed to a comparator. The comparator analyzes all valid incoming signals. The best signal is selected and fed to the transmitter or transmitters covering the desired area.

The best channel selection may be made either on a continuous—almost syllable-by-syllable—basis, or on a once-per-transmission basis. The once-per-transmission mode may be desirable for sites that cover low-signal-level areas where communication with mobiles otherwise may be lost when received sinad levels are consistently low. This mode may be desirable, moreover, when data transmission is involved



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because frequent phase changes in received signals would be undesirable.

Network configurations

Two basic SINAD voting system configurations are available to the system designer, the star and the linear-spur.

► *Star network*—Figure 1 on page 30 shows the more common star network, in which satellite receivers are placed throughout the coverage area. They feed signals to a centralized voting shelf. This central site may include the transmitter for the coverage area and another receiver, but this is not essential.

The links may be wireline or radio, and they may use tone-on-idle or E/M signaling to indicate receiver gate operation.

Selected audio may be passed to a control room or to the local transmitter for repeater applications. If the system transmitters are located around the coverage area, the voted audio can be selectively routed to them or passed to all transmitters. A word of caution: If multiple transmitters are used simultaneously on identical frequencies and if their coverages overlap, quasi-synchronous simulcasting must be used to avoid problems associated with frequency drifts and offset.[3]

► *Linear-spur*—Figure 2 on page 36 shows the linear-spur network. It resembles the star network and is more appropriate for covering long-and-thin-shaped areas, such as highways and railways. The figure shows coverage along a highway.

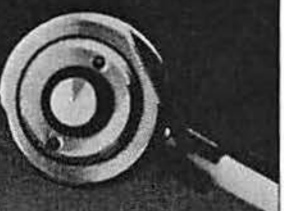
Remote base stations feed their signals to a central control room via three voting systems operating in series. With this scheme, any mobile can access the system anywhere along the highway using a common, single mobile transmitter frequency, and all mobiles use a common receive frequency. The voters automatically retransmit on the correct transmitter or on a transmitter specifically selected by the central control room operators.

SINAD voter operation

On the test bench, SINAD measurements normally are simple to make. A 1kHz test tone modulates the RF test generator, and the receiver's audio output level is measured two ways: directly and through a sharp, 1kHz notch filter to give the SINAD value. Nonetheless, when only normal speech or signaling is present, measuring SINAD is more difficult.

One method that represents the various schemes available in commercial voting systems is shown in Figure 3 on page 38. Each incoming received audio signal is amplified logarithmically, increasing low-level signals and providing less gain for high-level signals. This stage is followed by an envelope detector that detects the gain-limited audio delivered by the previous stage.

The valley detector then measures the difference between the detected audio signal's peak, corresponding to the SIGNAL + NOISE + DISTORTION component of a SINAD measurement system and the signal's valleys, which correspond to the



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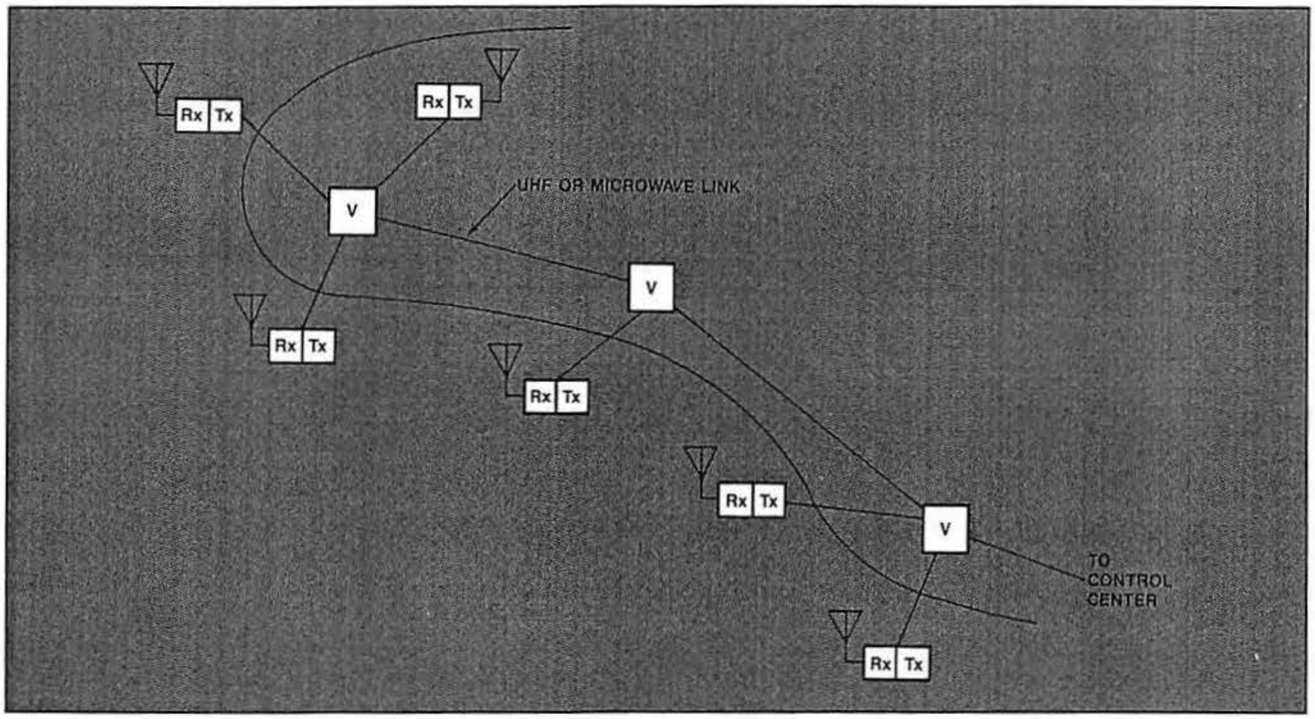
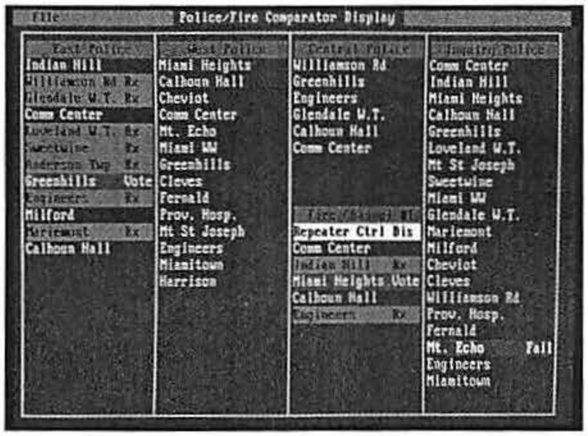


Figure 2. The linear-spur network resembles the star network. It is more appropriate for covering long-and-thin-shaped areas. In this example, a highway system's remote base stations feed signals to a central control room via three voting systems operating in series.



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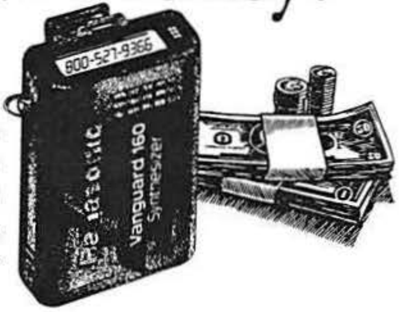

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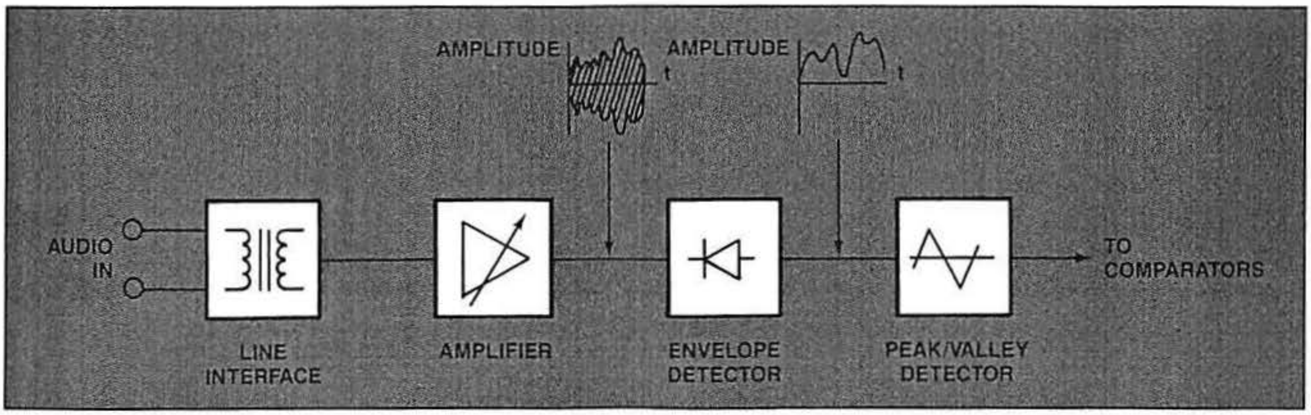

Figure 3. In this configuration of a commercially available voting system, incoming received audio signals are amplified logarithmically. An envelope detector detects gain-limited audio delivered by the previous stage. The *valley detector* measures the difference between the detected audio signal's peak, corresponding to the SIGNAL + NOISE + DISTORTION component of a SINAD measurement system and the signal's valleys, which correspond to the no-signal NOISE + DISTORTION of SINAD. The resulting dc output of this difference-detector then represents the instantaneous received SINAD.

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This brief overview ignores some highly critical areas of the various circuit blocks, especially the important dynamic range constraints, the required system signal timing and the decision logic that surrounds these stages to ensure that only valid signals are analyzed and passed to the comparators.

It is essential that no audio compression or limiting occurs in the receiver audio stages or intermediate linking equipment prior to being presented to the voter for analysis. If compression or limiting occurs, then the log amplifier may limit or amplify the low-level signals excessively. The following envelope detector stage may then limit, and the

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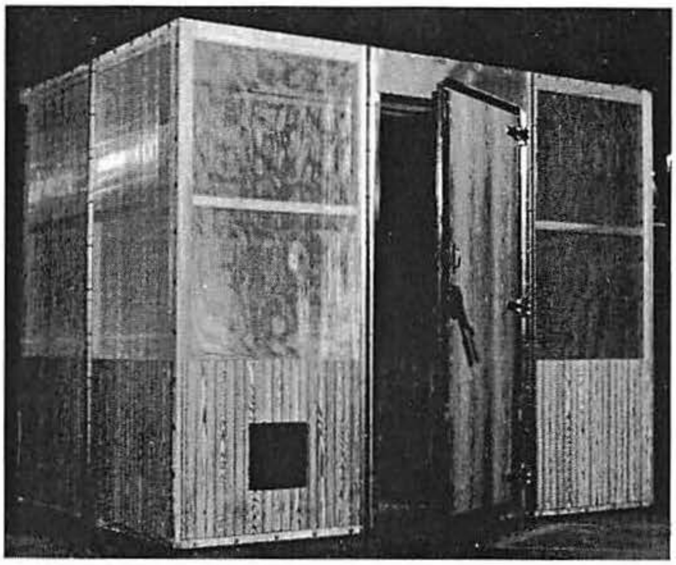

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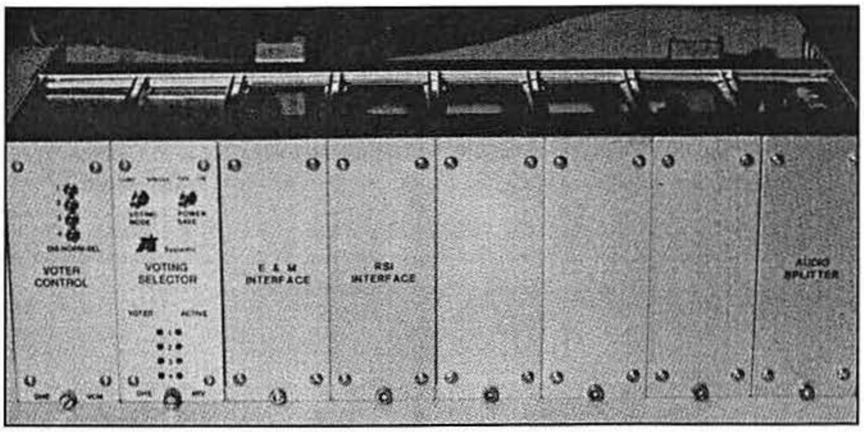

A UHF diversity rack shows two monitored UHF shelves (top) and a voting system for diversity combining of the two UHF receivers on the UHF shelves.

resulting response of the valley detector may indicate a poor SINAD for that channel. If the channel is limiting badly, this situation inadvertently may indicate the truth—that a bad-quality signal is being received—but for the wrong reason.

Other SINAD measurement techniques adopted in SINAD voter equipment attempt to avoid the problem through the use of window detection and other methods, but all systems can be affected badly by gain limiting and compression.

Time constraints

Fast voting system operation is crucial to successful radio system operation, especially if selective calling or data transmissions are to be used. Excessive delays in decision logic require the user's mobiles to adopt lengthy lead-in delays prior to sending selective calling (selcal) or data transmissions. In the latter case, the lead-in delay can lead to extremely poor overall system performance, even with the best high-speed data terminal equipment. If the system must wait for 500ms before the transmission channel is ready, for example, a five-digit selcal sequence at 20ms per tone, which usually takes 100ms to 150ms to send, will require 600ms to 650ms to achieve the same result.

Decision logic

Decision logic must ensure that only valid received signals enable the SINAD voter detectors and faults such as lost or disfunctional audio lines are able to be cleared automatically by detection circuits and timers, or manually, if required. For example, the detectors almost invariably see valid channels that have no audio signals as having the best SINAD because noise and distortion on faulty lines is extremely low. This problem can be avoided with tone-on-idle

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Timing

It is essential to ensure that signaling applied to the voter is timed correctly. In particular, a receiver gate signal must not arrive before valid audio arrives. If it does, the voter automatically selects the channel with the receiver gate signal and remains on it until audio arrives at the inputs. Then it makes a proper selection.

If the voter time constraints provide hysteresis to hold a selected channel for a nominal 200ms (normally, an acceptable period), it may take 250ms to select a correct channel following an invalid selection based on the early arrival of a receiver gate signal.

If selective calling or automatic number identification (ANI) signals are used in such a system, and if they are sent at the beginning of transmissions, then the selcal and ANI data will be missed partially or completely if erroneous timing occurs. Figure 4 on the left shows

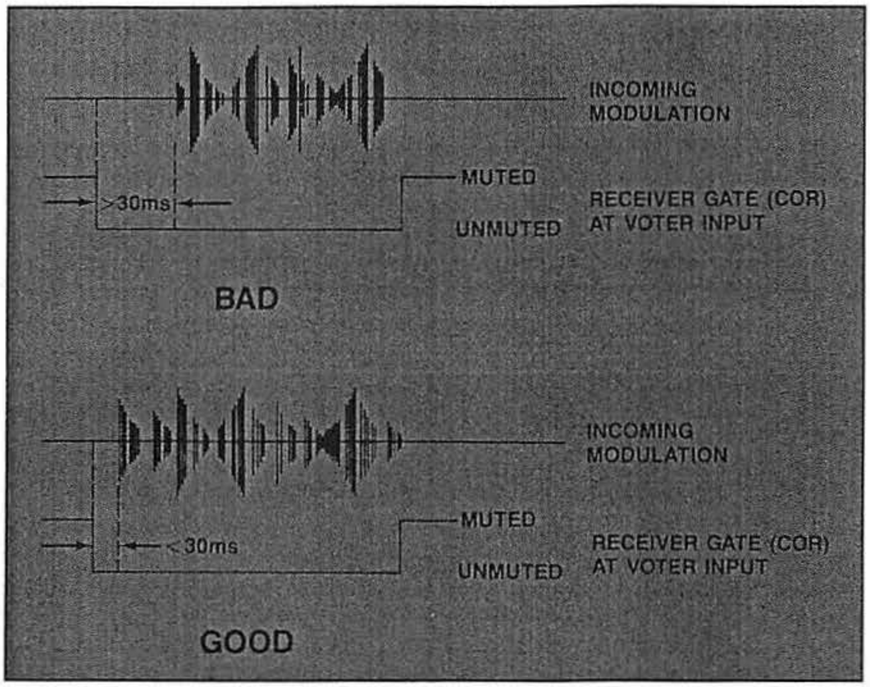

Figure 4. If selective calling or automatic number identification (ANI) signals are sent at the beginning of transmissions, the selcal and ANI data will be partially or completely missed if erroneous timing occurs. The drawing shows examples of good and bad gate signal sequences.

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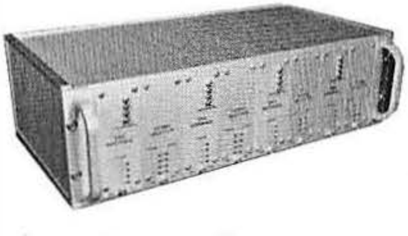

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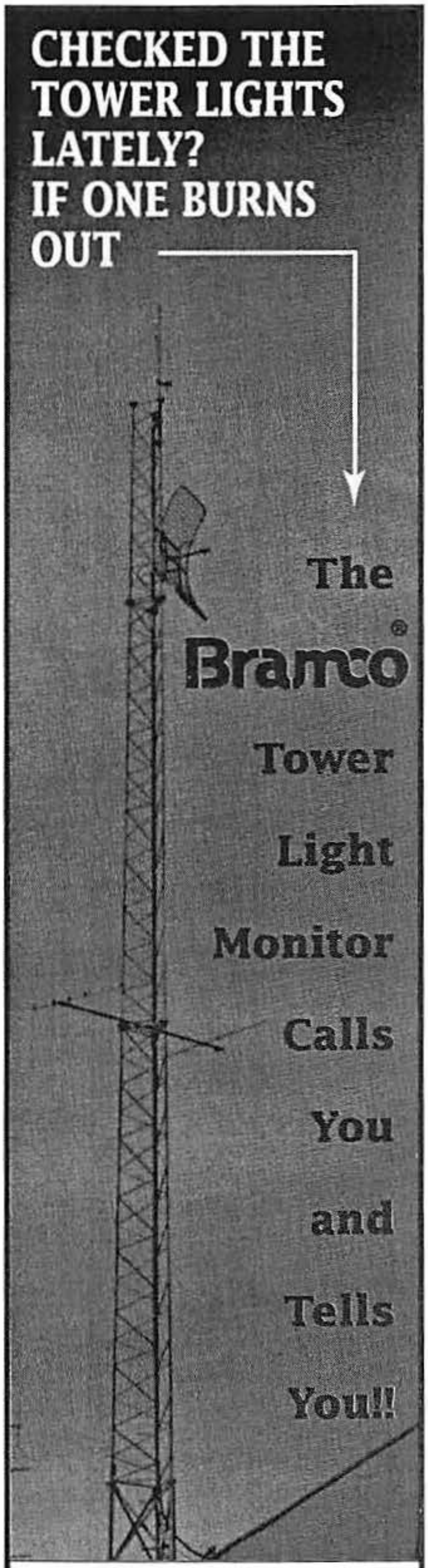

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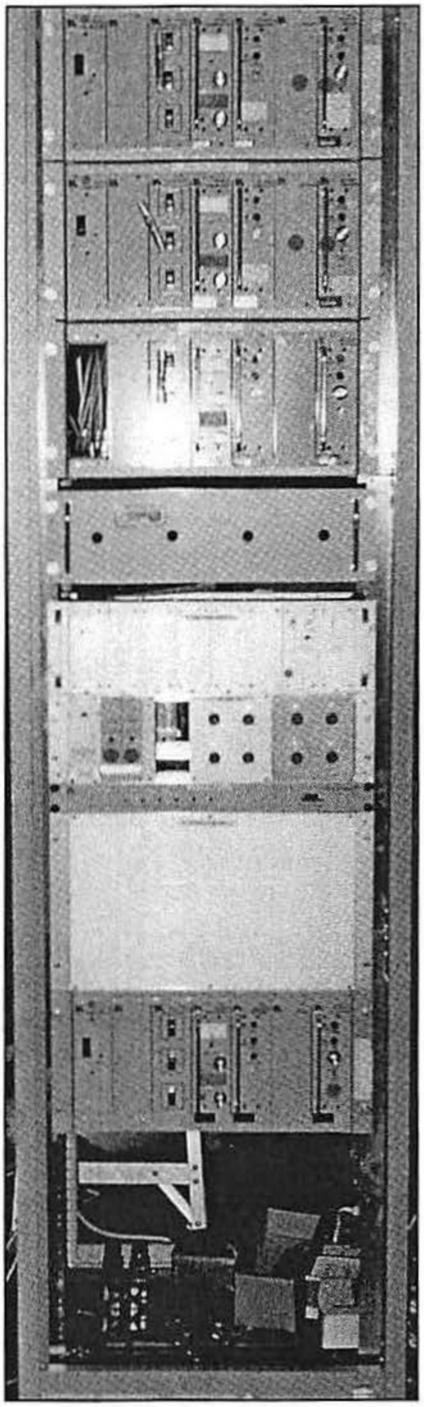


A typical four-channel SINAD voting system shelf with an optional four-wire E/M wire interface, received SINAD indicator (RSI) interface and an audio splitter for audio retransmission.

good and bad examples of gate signal sequences.

The use of CTCSS signaling within voting systems is one example in which such timing sequences can be experienced, and careful design checks must be made to ensure correct operation. System alignment must be handled carefully to ensure that all factors are checked.

Frequency response

Where several voting systems are set up in series, as in the linear-spur configuration, the system frequency response is composed of the sum of the individual equipment frequency responses. If voters are in sequence, and if each has a 300Hz-to-3,000Hz, ±3dB frequency response characteristic, the output from a series of three such systems will exhibit a 9dB rolloff at 300Hz and 3,000Hz. This is not the way to engineer a professional sound on a mobile network.

It is important to keep edge rolloff and in-band ripple to a minimum. In networks designed by the writer, the specification adopted is 300Hz to 3,000Hz ±0.2dB. A simplex frequency response tailoring network is added to each voter to ensure that the specification is met. With five such voters in series, the network output should be better than ±1dB across the frequency range.

System alignment

The following describes a typical alignment sequence for a voting network. It is essentially valid for almost all system configurations.

(1) All outstation radio equipment should be aligned and tested fully, and correct line levels should be set. If outstations use CTCSS tones, they should be checked, and the modulation levels should be measured.

(2) Align and test radio linking equipment, especially where CTCSS regeneration is to occur. Where fixed lines are to be used, they should be tested to ensure that they are noise-free and that their frequency responses are correct.

(3) Align and test the voting shelf, initially using a SINAD voter alignment test set if available and using valid system audio line levels.

Do not use continuous audio tones for SINAD voter testing and alignment because continuous tones do not provide the audio detectors with the necessary peak-and-valley sequences. SINAD voter test sets provide gated tones that partially simulate speech or signaling. The gated tones allow correct alignment and permit operation to be tested fully. A proper test set lets the voter be tested completely and independently of the networks and allows network problems to be isolated more rapidly.

(4) Check the SINAD voter shelf for at least 3dB hysteresis between channels to ensure that minimal interchannel selection "chatter" occurs in service when mobiles present nearly equivalent SINAD inputs to multiple receivers. Hysteresis of more than 6dB should be avoided to ensure that smooth interchannel selection occurs within the voter. Signal acquisition time should be less than 50ms after receipt of a valid gate signal, and channel hysteresis should provide a hold time of about 200ms. Shorter hold times produce excessive "chatter," and longer times delay valid channel selections.

(5) Check audio output levels from the voter and the presence of a valid transmitter key signal when a valid receiver gate input is received.

(6) Test the signal/gate timing between each outstation and the inputs to the voter shelf. Use a modulated RF signal generator as a source for the receiver, whose RF output is gated slowly on and off (at two-second intervals, for example), and observe (using a storage oscilloscope at the voter) the arrival of the receiver gate signal and the received modulation. Modulation may precede slightly or be coincidental with the gate signal, but it must not be more than 20ms or 30ms behind the arrival of a valid receiver gate signal. Check that no modulation gaps occur during the switching between receivers on a common shelf.

Shorter hold times produce excessive "chatter," and longer times delay valid channel selections.

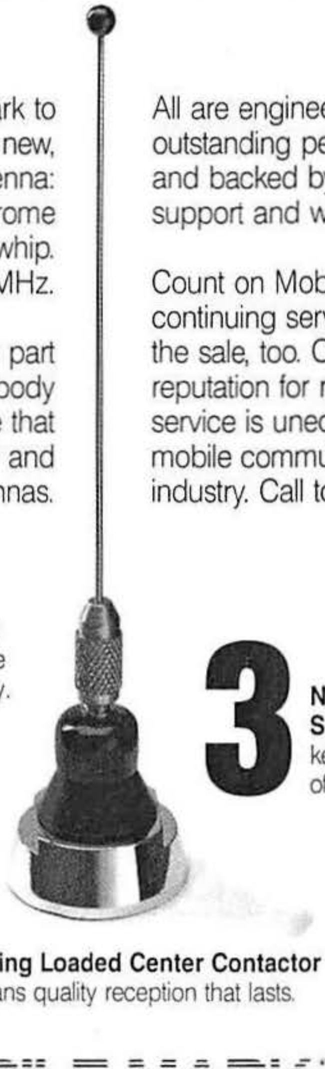
(7) Check the audio level at each transmitter site to ensure correct modulation levels are maintained. If at all in doubt, check the link or line audio frequency response to ensure an optimum audio response is present—preferably better than ±1dB at the band edges for any individual audio path.

Other voter system uses

► *Diversity*—SINAD voting systems can be used for receiver diversity applications. Diversity techniques improve the communications path between mobiles and the base stations by combining multiple signals and reducing the periodic deep fading that occurs when mobiles move about the coverage area.

Space diversity improves the received

(continued on page 78)



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signal by combining the outputs of multiple receivers (usually two) whose antennas are spaced by more than a quarter wavelength. Polarization diversity uses a similar setup with two antennas of different polarization. The technique works because signals received by separated antennas are unlikely to suffer simultaneous fading.[4]

A voting system can be used to select automatically the best output signal from two or more receivers fed from diversity antenna systems. Typically, average received signal strengths are approximately 4dB better for two-receiver diversity combining and as much as 8dB better when four receivers are combined, as compared to a single receiver. The greatest improvement is in the reduction in deep, sharp fades that may reach 10dB or more, even when two receivers are combined with either space or polarization diversity.[5]

► *Improved coverage*—Where well-defined areas must be covered, such as on a highway running north and south from the radio base station site, using two receivers connected to individual yagi antennas pointed north and south, for example, provides well-defined, high-gain coverage. This method uses standard antennas, as compared to the alternative of purchasing a specially designed, phased-antenna system.

► *Duplicated systems*—By combining two receivers through a SINAD voter, system redundancy for improved reliability can be provided. Redundancy may be especially useful at remote sites and sites with difficult access.

SINAD voting systems provide a powerful tool for planning systems that require wide-area coverage on common channels. SINAD voters can provide a means for co-located receivers to be added into a communications network, particularly where polarization-, space- or directional-diversity reception systems are being considered.

Care is required when implementing such systems, but experience has shown that SINAD voting systems cover large areas with ease. User satisfaction is especially high when operators no longer have to select zones and channels.

References

1. Holbeche, R.J. (editor), *Land Mobile Radio Systems*, Chapter 7, IEE Telecommunications Series 14, Peter Peregrinus Ltd., 1985.

2. "Quasi-Synchronous Operation of Two or more Transmitters," Pye Telecommunications Ltd., Engineering Notes, Pub. Ref. No. TSP361/2, April 1980.

3. Gray, G.D., "The Simulcasting Technique: An Approach to Total-area Coverage," *IEEE Transactions On Vehicular Technology VT-28,* May 1979.

4. Parsons, J.D. and M. Henze, "An Evaluation of Certain Diversity Reception Techniques for Mobile Radio," *IERE Conference Proceedings No. 33,* 1975.

5. Lee, W.C.Y., *Mobile Communications Engineering*, Chapter 10, McGraw-Hill, 1982.

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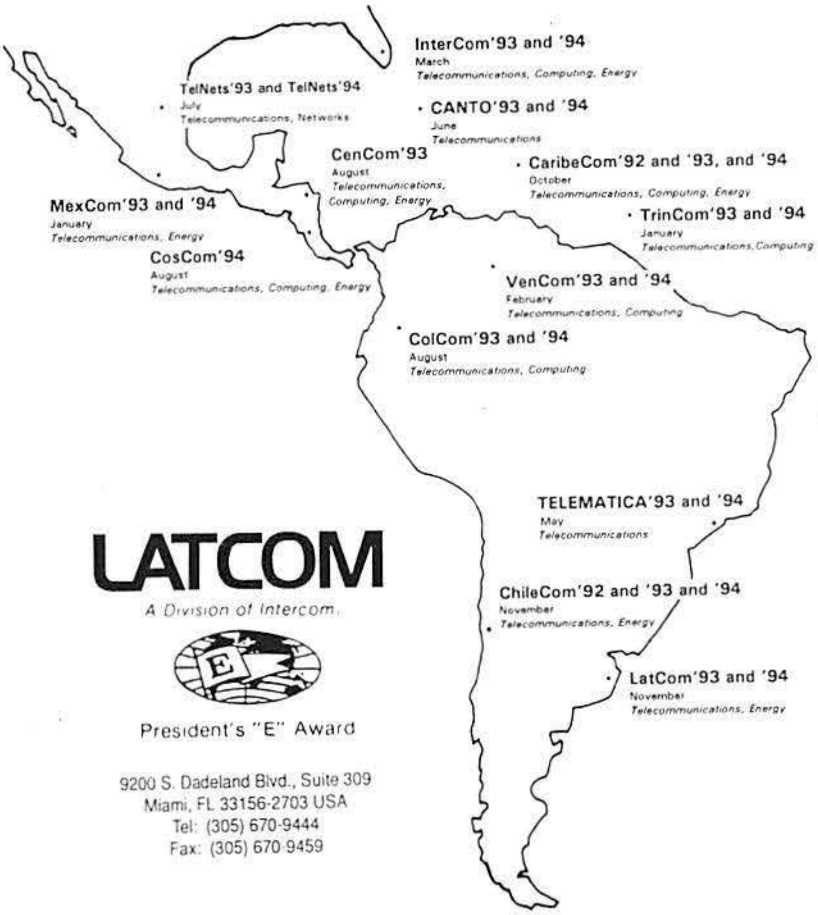

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